same rule is needed in dealing with mean proportionals in geometry.

Cube root is harder and should be postponed until it can be studied as a particular case of Horner's method of solving equations approximately.

Passing to algebra, we find that a teacher's chief difficulty is the tendency of his pupils to use their symbols in a mechanical and unintelligent way. A boy may be able to solve equations with great readiness without having even a remote idea of the connection between the number he obtains and the equation he started from. And throughout his work he is inclined to regard algebra as a very arbitrary affair, involving the application of a number of fanciful rules to the letters of the alphabet.

If this diagnosis is accepted, we shall be led naturally to certain conclusions. It will follow that elementary work in algebra should be made to a great extent arithmetical. The pupil should be brought back continually to numerical illustrations of his wcrk. The evaluations of complicated expressions in *a*, *b* and *c* may of course become wearisome; a better way of giving this very necessary practice is by the tracing of easy graphs. Such an exercise as plotting the graph $y = 2x - \frac{x^2}{4}$ provides a series of useful arithmetical examples, which have the advantage of being connected together in an interesting way. Subsequently, curve-tracing gives a valuable interpretation of the solutions of equations. Experience shows that this work is found to be easy and attractive.

With the desire of concentrating the attention of the pupil on the meaning rather than the form of his algebraical work, we shall be led to postpone certain branches of the subject to a somewhat later stage than is usual at present. Long division, the rule for H.C.F., literal equations and the like will be studied at a period when the meaning of algebra has been sufficiently inculcated by arithmetical work. Then, and not till then, will be the time to attend to questions of algebraic form.

But at no early stage can we afford to forget the danger of relapse into mechanical work. For this reason it is much to be wished that examining bodies would agree to lay less stress upon facility of manipulation in algebra. Such facility can generally be attained by practice, but probably at the price of diminished interest and injurious economy of thought. The educational value of the subject is sacrificed to the perfecting of an instrument which in most cases is not destined for use.

To come to particulars, we think that undue weight is often given to such subjects as algebraic fractions and factors. The only types of factors which crop up continually are those of $x^2 - a^2$, $x^2 \pm 2ax + a^2$, and, generally, the quadratic function of x with numerical coefficients.

In most elementary algebra books there is a chapter on theory of quadratic equations in which a good deal of attention is paid to symmetric functions of roots of quadratics. No further use is to be made of this until the analytical theory of conics is being studied. Might not the theory of quadratics be deferred until it can be dealt with in connection with that of equations of higher degree?

Indices may be treated very slightly. The interpretation of negative and fractional indices must of course precede any attempt to introduce logarithms; but when the extension of meaning is grasped, it is not necessary to spend much more time on the subject of indices; we may push on at once to the use of tables.

It will be seen that our recommendations under the head of algebra are corollaries of two or three simple guiding thoughts, the object in view being—to discourage mechanical work; the means suggested—to postpone the more abstract and formal topics and, broadly speaking, to arithmeticise the whole subject.

The omission of part of what is commonly taught will enable the pupil to study, concurrently with Euclid VI., a certain type of diluted trigonometry which is found to be within the power of every sensible boy. He will be told what is the meaning of sine, cosine, and tangent of an acute angle, and will be set to calculate these functions for a few angles by drawing and measurement. He will then be shown where to find the functions tabulated, and his subsequent work for that term will consist largely in the use of instruments, tables and common sense. A considerable choice of problems is available at once. He may solve right-angled triangles, work sums on "heights and distances," plot the graphs of functions of angles, and make some progress in the general solution of triangles by dividing the triangle into right-angled triangles. Only twc trigonometrical identities should be introduced—

$$\sin^2\theta + \cos^2\theta = 1, \text{ and } \frac{\sin\theta}{\cos\theta} = \tan\theta.$$

In short, the work should be arithmetic, and not algebra.

Formal algebra cannot be postponed indefinitely; perhaps now will be the time to return to that neglected science. We might introduce here a revision course of algebra, bringing in literal equations, irrational equations, and simultaneous quadratics illustrated by graphs, partial fractions, and binomial theorem for positive integral index. Side by side with this it ought to be possible to do some easy work in mechanics. Graphical statics may be made very simple; if it is taken up at this stage, it might be well to begin with an experimental verification of the parallelogram of forces, though some teachers prefer to follow the historical order and start from machines and parallel forces. Dynamics is rather more abstract; a first course ought probably to be confined to the dynamics of rectilinear motion.

It is not necessary to discuss any later developments. The plan we have advocated will have the advantage of bringing the pupil at a comparatively early stage within view of the elements of new subjects. Even if this is effected at the sacrifice of some deftness in handing *a*, *b* and *c*, one may hope that the gain in interest will be a motive power of sufficient strength to carry the student over the drudgery at a later stage. Some drudgery is inevitable, if he is ultimately to make any use of mathematics. But it must be borne in mind that this will not be required of the great majority of boys at a public school.

We beg to remain, gentlemen,
Yours faithfully,

G. M. BELL, Winchester.
H. H. CHAMPION, Uppingham.
H. CRABTREE, Charterhouse.
F. W. DOBBS, Eton.
C. GODFREY, Winchester.
H. T. HOLMES, Merchant Taylors' School.
G. H. J. HURST, Eton.
C. H. JONES, Uppingham.
H. H. KEMBLE, Charterhouse.
T KENSINGTON, Winchester.
E. M. LANGLEY, Bedford Modern School.
R. LEVETT, King Edward's School, Birmingham.
J. W. MARSHALL, Charterhouse.
L. MARSHALL, Charterhouse.
C. W. PAYNE, Merchant Taylors' School.
E. A. PRICE, Winchester.
D. S. SHORTO, Rugby.
A. W. SIDDONS, Harrow.
R. C. SLATER, Charterhouse.
H. C. STEEL, Winchester.
C. O. TUCKEY, Charterhouse.
F. J. WHIPPLE, Merchant Taylors' School.

CONFERENCE OF SCIENCE TEACHERS.

ONE of the most important of the many educational conferences which it has become customary to hold during the Christmas vacation is that arranged under the auspices of the Technical Education Board of the London County Council. The custom of inviting teachers of science from all parts of the country to attend meetings in London, to discuss the best methods of imparting instruction in the branches of science taught in schools and colleges, was inaugurated four years ago, and each successive year has seen a substantial increase in the attendance. While in 1899 fewer than a hundred teachers, inspectors and others responded to the invitation of the Technical Education Board, there were present at the meetings held on Thursday and Friday last at the South-Western Polytechnic, Chelsea, upwards of four hundred persons, among whom were representatives of every stage of science teaching.

The vice-chairman of the London Technical Education Board, Mr. T. A. Organ, presided at the first meeting and, in a speech welcoming the teachers present, referred to the neglect of science teaching in this country in the past and contrasted this with the admirable efforts made in Germany since the opening of their first chemical laboratories in 1827. As indicating the amount of leeway we have as a nation to make up, he pointed to the fact that there are nearly 10,000 more or less well-trained chemists employed in German factories, and, as half of them have undergone a complete course of several years' training in the technical high schools, it is not surprising that Germany should be gradually securing markets in which originally British trade was supreme. It is unnecessary to repeat

here the examples which Mr. Organ cited, since they have been many times referred to in NATURE. The Technical Education Board could profitably expend, said the chairman, two millions on the improvement of the provision for research in the chemical and engineering sciences alone.

Hygiene as a School Subject.

Papers were read by Miss Alice Ravenhill, on the teaching of hygiene, and by Dr. Francis Warner, on mental school hygiene. The former paper discussed several points. Can our schools be made to contribute to the work of raising the standard of health in the country? If it is desirable to teach hygiene in schools, how will the curriculum be affected by the addition of this subject? In what grades of schools should hygiene find a place, and what are the best methods of teaching it? It was rightly pointed out that hygiene is really the application to the health of the individual of most other sciences, and that instruction in physics and chemistry may very well be given a useful bias by pointing out their applications in the particular problems with which hygiene is concerned. Miss Ravenhill compared the teaching of hygiene in this country with what she had seen in the American schools during her recent visit to the States, and indicated several customs which might very well be imitated by English teachers.

Dr. Warner explained how the study of mental hygiene could be made to assist the work of the teacher. Since all mental action is expressed in movement and its results, the teacher can, by noting carefully the expression, balance and action in movement and response, of the pupil, learn much of the modes of action in the brain centres.

Natural History Teaching.

At the second meeting the chair was taken by Prof. Tilden, F.R.S., who in the course of his remarks gave it as his opinion that every educated man should possess a broad general acquaintance with the facts of biological science, and that consequently all boys and girls should have an opportunity of studying natural history. The best time for such study is probably in the holidays, for in these days of crowded school time-tables and compulsory organised games the children have no leisure hours in term time. This holiday work should not be in the hands of the ordinary school staffs, who cannot dispense with the rest of vacation weeks, but be under the care of special holiday instructors.

Addresses were delivered by Mr. F. E. Beddard, F.R.S., on the teaching of natural history, and by Prof. W. B. Bottomley, on the value of natural history collections for teaching purposes. Both speakers gave a number of reasons why natural history should be taught in schools, urging that in educative influence it is second to no subject. Mr. Beddard maintained that the teaching should be in the hands of experts, who might very well be itinerant lecturers visiting each school once or twice a week. He showed by means of a brief comparison of the horse and the donkey how natural history teaching can be conducted on research lines and so form an excellent way of training the observation and reasoning powers. He also made it clear that there need not be much expense attending the introduction of natural history into school teaching. Prof. Bottomley distinguished between natural history collections and museums; while the former are capable of assisting the teacher very much, the ordinary museum is of little value. The natural surroundings of all animals exhibited should be imitated as closely as possible, and the objects should be typical of the neighbourhood in the first place, but be supplemented by others characteristic of the great divisions of the animal kingdom.

Schemes of Nature-Study.

The principal of the University of London, Prof. A. W. Rücker, F.R.S., presided at the third meeting. Mr. R. Hedger-Wallace described American systems of nature-study. He followed the classification of the methods in common use in the United States which was recently made by Prof. Hodge, of Clark University, and gave the distinguishing characteristics of each of the eleven divisions recognised by Prof. Hodge. Most of the American schemes of nature-study are marked by an undesirable pretentiousness which teachers in this country would do well to avoid. Perhaps the best of the American methods is that of Cornell University, drawn up by Prof. Bailey, and many of the schedules and instructions issued to teachers throughout the States by the authorities of Cornell University might be copied in this country with great advantage to the teaching of nature-study in our own rural schools. Mr. Hedger-Wallace particularly condemned the sentimentality developed by much of the teaching in American schools.

Mr. D. Houston gave an eminently practical account of the plan for teaching nature-study in schools which he has worked out for the Essex County Council. In this scheme it is rightly recognised that the success of any method depends ultimately upon the equipment and enthusiasm of the instructor. Consequently great stress is, in Essex, laid upon the preparation of teachers for their work. A three years' course has been inaugurated, and in the first two of these teachers are trained by lectures and laboratory work in the branches of science which underlie any serious work in nature-study; while in the third year the student prepares a detailed monograph upon a special plant, a course which is found to give an insight into the methods of research and to help the teachers to put the children into the right attitude towards the work. Mr. Houston exhibited an interesting series of exercises performed by teachers in training and by children in schools, which showed very conclusively that the work in Essex is being done on scientific lines.

Prof. Rücker summarised the addresses and indicated the lines the subsequent discussion might profitably take. He insisted that, in the education of children, science must be brought into close connection with art and literature. Science should teach how to observe and how to reason from the observations made, but for the due expression of what has in this way been learnt a course in drawing and literature is imperative. He also pointed out that while schemes of study which have been found to work well in some schools in certain circumstances are valuable to all teachers, such courses of study must not be adopted *en bloc* by teachers. Every instructor should be continually improving his scheme of study, modifying it to meet the peculiar needs of his own classes.

During the short discussion which followed, Dr. Gladstone, F.R.S., referred to the work under the London School Board which he helped to systematise.

Technical Education in Rural Districts.

In the absence of the Countess of Warwick, Prof. H. E. Armstrong, F.R.S., presided at the concluding meeting of the conference. Mr. Hennesey, the principal of Lady Warwick's School, Bigods Hall, Dunmow, described the equipment and curriculum of his school, which he explained was a school of science in which the courses of study for rural schools drawn up by the Board of Education were adopted. The school at Bigods is attended by both boys and girls, and no disadvantages have been found to result from the plan of co-education. Mr. Hennesey explained that a difficulty is experienced when the third year is reached, since it is found that only 50 per cent. of the third-year students intend to remain in the country to take up agricultural and horticultural pursuits. Instead of making the work of the third and fourth years purely technical a compromise is effected, so that those children who will work in urban centres may not suffer. Purely technical subjects are excluded, and great care is taken to make all subjects as educative as possible. It has not been found that the general education of the pupils suffers from the agricultural bias given to the teaching.

Prof. Meldola, F.R.S., passed in review the pioneer work in secondary and technical education in rural districts which has been accomplished in Essex. He concerned himself chiefly with the difficulties which have been overcome. He said that the sporadic teaching of insufficiently educated adults which is so common in many counties does little good. The best kind of technical education is that given by experts to classes of suitably trained youths. Rural technical education will not be satisfactory until an intimate connection between the elementary and secondary school is established. At present few children from the elementary school pass on for a further period of study to the secondary school provided, like the school at Bigods, with every facility for teaching the broad principles of agricultural and horticultural practice. A thorough system of scholarships by which the best children of the elementary school could pass on to the secondary school would have excellent results.

Prof. Armstrong, in bringing the conference to a close, insisted that the success of schemes of technical instruction is in no way proportionate to the costliness of the equipment. Simple appliances are best, and workshops are more productive of good

work than elaborately fitted laboratories. Desk work must be dethroned to a large extent and the pupils be given more time in the open air.

The exhibition of home-made apparatus was not so good as usual this year. Judging from the remarks of many teachers present at the conference, this exhibition has in previous years been regarded as one of the most helpful of the items on the programme of events, and Dr. Kimmins, to whose energy the success of the conferences is due, should develop this side of the annual meetings as largely as possible in future.

A. T. SIMMONS.

A NEW RANGE-FINDER.[1]

THE instrument designed by Prof. Forbes is intended only for use with rifle fire. It is not suitable for long-range artillery, or for the Navy. This infantry type is by far the most difficult to produce, because, in addition to accuracy, extreme portability is an essential feature. At the same time, the infantry are more in need of some addition to their present resources than any one else, and the urgent need of such an instrument has been proclaimed and re-echoed by all our officers who have returned from the war in South Africa.

All methods of optically measuring the distance of an inaccessible object depend on using a base of known length, which must be measured on the ground, or else be part of the instrument. In the latter case the instrument can usually be worked by one man, who can find the distance without changing his position. This class of instrument is sometimes spoken of as short-base range-finders. Numerous patents for such instruments have been applied for; but the difficulties in the way of ensuring accuracy are so great that only one type has ever been perfected and generally used. The Barr and Stroud range-finder has been adopted by the Navy with most satisfactory results, and this has proved the fact that a short base (4½ feet) is not inconsistent with accuracy. For the use of infantry, however, where extreme probability, and accuracy, and suitability for ill-defined objects, such as men, bushes, rocks, &c., are essentials, this is an unsuitable instrument.

In the Barr and Stroud instrument the two images of a distant object are seen with one eye, hence the object appears to be double until the micrometer arrangement has been so moved as to make a coincidence of the two images, when the scale reading of the micrometer gives the distance directly. Now in naval work, for which this instrument is made, a ship, or its mast or funnel, is very sharp against the sky, and the coincidence can easily be made; but this method is almost valueless in the field. A bush, or a rock, or a man is an object so ill-defined, especially against certain backgrounds, that in attempting to make a coincidence you may move one picture in the telescope over the other for a considerable angle before you are sure that it is double. The difficulty has been got over by Messrs. Carl Zeiss and Prof. Forbes, who make use of stereoscopic vision in the new range-finder.

The instrument consists of a folding aluminium base, 6 feet in length, and a field glass. The base is a square tube hinged at its middle, and folds up to 3 feet 6 inches. Each half has at each end a doubly reflecting prism. The rays of light from a distant object strike the outer pair of these four prisms, are reflected at right angles along each tube, and are then reflected at the two middle prisms into the two telescopes of the binocular fixed to the base, in directions parallel to the original rays intercepted by the outer prisms. It is the measurement of the angle between these rays that tells the distance of the object looked at. This angle is measured by two vertical wires, one in each telescope, seen by the two eyes. One of the wires is fixed, the other is moved by a micrometer-screw until the two wires appear as one, while the object is seen distinctly. This gives the distance accurately to 2 per cent. even at 3000 yards. But now stereoscopic vision comes in and gives far greater accuracy. The wire seems to stand out solid in space, and the slightest turn of the micrometer screw causes the wire to appear to be nearer or farther than the object looked at, and when the wire appears to be at exactly the same distance the micrometer reading gives the distance with an accuracy far greater than that attainable by observing the duplication of images on the retina.

This range-finder can be used in a variety of positions. The more steadily it is held the more accurate the result. A standing position is the least steady. When kneeling, using only half the base, the other half may be bent down at right angles, and so form a leg which serves as a rest on the ground. The most easy position is sitting with the elbows resting on the knees. Another steady position is lying flat on the ground facing the object (Fig. 1). In every one of these positions you can take advantage of cover. Since the eyes are virtually at the extremities of the base, the observer may stand, sit, kneel, or lie behind a tree, bush, rock, ant-hill, horse, comrade, or waggon, and will not only be more able to work without sensation of danger, but without drawing the fire of the enemy on his comrades.

Lord Kitchener having expressed a desire to see the range-finder tested in the field, Prof. Forbes has proceeded to South Africa with his instrument, and a thorough examination of its efficiency will be made under practical conditions.

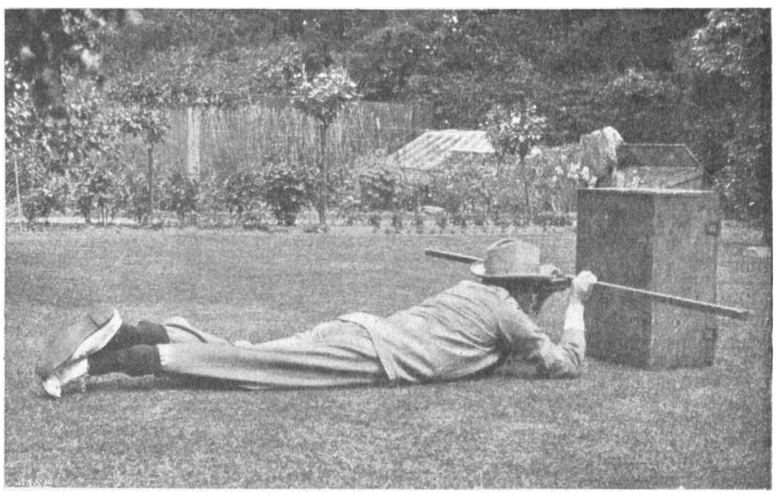

FIG. 1.—Range-Finder in use behind cover.

[1] Abstract of a paper read before the Society of Arts on December 18, 1901, by Prof. George Forbes, F.R.S.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

THE Prince of Wales having consented to be nominated as Chancellor of the University of Wales, has been elected to that office in succession to His Majesty the King, who has assumed the title of Protector of the University.

THE executive committee of the Carnegie Trust met at Edinburgh on Monday. The secretary and treasurer submitted their reports for the period ended December 31, 1901, showing that fees have been paid by the Trust to 2441 students, amounting to the sum of 22,941*l*. 16*s*. 6*d*. It was arranged to hold the annual meeting of the trustees in London, at which the first report of the executive will be submitted.

AT a special meeting of the Governors of University College Dundee, on January 8, Sir W. O. Dalgleish intimated that he would provide a sum of 5000*l*. for the building of the new medical school, and an additional sum of 5000*l*. towards the extinction of the debt on the College. This latter sum will be payable only if within a certain reasonable time sufficient money is subscribed to make up the remaining sum, the balance of